OVARIAN FUNCTION IN THE COW AFTER INDUCTION OF UTERINE MOTILITY

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The length of the oestrous cycle is reduced in the cow following daily subcutaneous injections of oxytocin during the week after oestrus (Armstrong & Hansel, 1959) but not after hysterectomy (Armstrong & Hansel, 1959; Anderson, Bowerman & Melampy, 1965). Ginther (1967) reported a unilateral luteolytic effect of the uterus in cows given oxytocin, suggesting a local utero-ovarian mechanism.

The uterus of the non-pregnant cow exhibited considerable muscular activity soon after intravenous injection of oxytocin (Simmons, Dracy & Essler, 1965). Uterine contractions became tetanic and began to subside 17 min later. Armstrong & Hansel (1959) have suggested that uterine afferent impulses may influence indirectly the secretion of hypophysial luteotrophin after the injection of oxytocin. It has been shown that electrical stimulation through the rectum can induce oestrous activity in anoestrous cows (Hays & Carlevaro, 1959). In the present study, uterine contractions were induced by electrical stimulation to determine if resulting uterine afferent impulses reduce the period of luteal maintenance.

Electrical stimulation of the uterus through the rectum was produced by an electro-ejaculator (Model E2X1, Plectron Corporation). Uterine motility was evaluated in four heifers by laparotomizing them and palpating the uterus during electrical stimulation. The stimulation was applied for 15 or 20 min at 8-hr intervals during the first 7 days of the oestrous cycle in thirteen heifers. One heifer was stimulated for 2½ hr once daily during this period. Frequencies of 20, 30 or 45 cycles/sec were used.

Four methods (A, B, C and D) of applying electrical stimulation were used in an attempt to find a scheme for causing a reduction of the oestrous cycle. In method A, the voltage was advanced slowly during 5 sec and then was decreased slowly to zero during 5 sec, with a rest period of 10 sec between stimulations. It was increased ¼ volt each time the stimulus was applied, to a maximum of approximately 13 volts. Maximal voltage then was applied rhythmically until the end of the stimulation period. Method B was the same as A, except that the maximum voltage was 4. Method C was the same as A, except that the rest period was 15 sec between 6 and 9 volts and 20 sec at voltages greater than 9. In method D, the voltage was increased slowly to 2½ and held at that level, without rest periods, for the duration of the stimulation period.

Before giving oxytocin to one heifer the lumbar and sacral nerves were anaesthetized to block most uterine afferent impulses. Each day, 150 ml of 2% procaine hydrochloride was infused into the epidural space through an indwelling polyethylene cannula (Bierschwal, 1960) 30 min before subcutaneous injection of 0.476 USP units oxytocin/kg body weight (Anderson *et al.*, 1965). Procaine was infused during a period of 90 min, and anaesthesia persisted for 30 min after infusion. The extent of anaesthetization was determined by pricking the skin. Cutaneous afferent nerves were anaesthetized caudal to the thirteenth thoracic vertebra.

Two heifers were hypophyseal stalk transected by the method of Anderson & Oxenreider (1967) on the day after the onset of oestrus. The importance of vascular connexions between the hypothalamus and hypophysis on the induction of luteal failure by exogenous oxytocin was evaluated in these animals. Oxytocin was injected subcutaneously (0.476 USP units/kg daily) for

TABLE 1

OESTROUS CYCLES IN HEIFERS AFTER ELECTRICAL STIMULATION THROUGH THE RECTUM

No. of heifers	Treatment	Oestrous cycle length (days)					
		Before stimulation		Stimulation		After stimulation	
		Average	Range	Average	Range	Average	Range
12	Electrical stimulation at 8 hr intervals*	20½	18 to 23	20½	17 to 23	21	18 to 24
2	Electrical stimulation at 8 hr intervals	19½	18 to 22	27	27 to 27	22	20 to 24
1	Probe placed in rectum, no electrical stimulation	23½	21 to 25	25	—	20	19 to 21

* One heifer was stimulated for periods of 2½ hr at intervals of 24 hr.

6 days following surgery. Jugular vein blood was collected at the 6th day and again at the 10th day after surgery. Ovarian venous blood and luteal tissue were obtained by laparotomy at the 10th day and analysed for progesterone as described by Masuda, Anderson, Henricks & Melampy (1967). Progesterone in peripheral blood was quantified by gas-liquid chromatography as described by Hashimoto, Henricks, Anderson & Melampy (1968).

In the laparotomized heifers, electrical stimulation by methods A, B and C produced uterine contractions in both horns simultaneously 5 to 6 sec after the stimulus was applied. These contractions occurred whenever the stimulus was applied and were followed in most instances with complete relaxation of the myometrium as the current was withdrawn. Contractions induced by method D were similar to spontaneous ones (uterine horns contracted asynchronously) for 9 min. After 9 min the uterus became tetanic.

Spontaneous contractions were unchanged until 5 min after the injection of oxytocin, and then they became tetanic. This tetanic state was similar to that observed with electrical stimulation (method D).

Oestrous cycles were 17 to 23 days in twelve of fourteen heifers in which uterine contractions were induced by electrical stimulation during the week

following oestrus (Table 1). Two heifers had cycles of 27 days. Rectal palpation indicated normal morphological development and regression of the corpus luteum in all animals.

Anaesthetization of the lumbo-sacral spinal nerves did not prevent the induction of luteal regression by exogenous oxytocin. A small corpus luteum was identified by rectal palpations and the heifer returned to oestrus on Day 9 of the cycle.

On the 6th day after hypophyseal stalk transection (Day 8 of oestrous cycle) the levels of progesterone in the peripheral blood of two heifers were 486 and 415 ng/100 ml blood. These were similar to a level of 442 ng in an unoperated heifer receiving oxytocin, but considerably higher than those in uninjected stalk-transectioned heifers (172 ± 13 ng) and intact control animals (254 ± 30 ng) at the same stage of the oestrous cycle (Henricks, Oxenreider, Anderson & Guthrie, 1967). By Day 10, control as well as uninjected stalk-transectioned animals had greater concentrations of progesterone in the peripheral blood than at Day 6, but the oxytocin-treated heifers had low values (17 and 21 ng/100 ml blood in the stalk-transectioned animals and 55 ng/100 ml blood in the unoperated heifer). Progesterone was not detected at Day 10 in the ovarian venous blood of the two hypophyseal stalk-transectioned heifers that were injected with oxytocin. The corpora lutea of these animals weighed 0.51 and 0.38 g at Day 10 compared with an average weight of 2.8 ± 0.14 g in untreated stalk-transectioned animals (Anderson, Oxenreider, Henricks & Melampy, 1966). One heifer had $20.2 \mu\text{g}$ progesterone/mg of luteal tissue, and no progesterone was detected in the corpus luteum of the other animal.

Results of this study indicate that uterine contractions induced by electrical stimulation are ineffective in causing luteal failure in the beef heifer. In most instances, the total stimulation time was 1 hr/day and this was divided into three periods of 20 min each. Since intravenous injection of oxytocin causes the uterus to contract for 17 min, it is probable that the effects of oxytocin given subcutaneously would last longer than 20 min. A stimulation period of $2\frac{1}{2}$ hr/day, however, did not affect the oestrous cycle of one heifer stimulated continuously with $2\frac{1}{2}$ volts. This method of stimulation produced tetanic contractions similar to those produced by oxytocin. The corpus luteum regressed after the injection of oxytocin even though the lumbo-sacral spinal nerves were anaesthetized. These nerves are a pathway for afferent impulses from the uterus.

Corpora lutea also regressed prematurely in hypophyseal stalk-transectioned heifers injected with oxytocin, whereas oestrous cycles were unchanged by electrically-induced uterine contractions. It appears, then, that early failure of the corpus luteum caused by exogenous oxytocin is dependent neither on the influence of uterine afferent nerve impulses nor on hypothalamic control of hypophyseal function.

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